Distributed Wireless Networks: Link Scheduling and Application Delay Modelling

Abstract

We address several problems that arise in a multihop wireless mesh network. First, we study the problem of joint congestion control, routing and MAC layer scheduling. We formulate the problem as an aggregate utility maximization problem and apply duality theory to decompose the problem into two sub-problems, namely, network layer congestion control and routing problem, and MAC layer scheduling problem. Given the link "prices", the source adjusts its rate based on the cost of the least-cost path to the destination, and sends traffic to the destination along the least-cost path, while link scheduling is carried out based on link prices.

Optimal link scheduling for a wireless network is known to be NP-hard. We explore the use of a known centralized greedy heuristic, and develop a *distributed algorithm* that can schedule independent links based on local information. While the link scheduling algorithm above is for a *given* set of link prices, the solution to our problem depends on the sequence of price vectors generated by the price update algorithm. This leads us to study convergence issues related to the price update algorithm.

Next, we develop a practical protocol which maximizes aggregate utility in a wireless mesh network. We simulate our protocol using Qualnet 4.5 and compare the result with a baseline protocol that uses IEEE 802.11 for link scheduling and AODV for routing.

Our proposed protocol requires the durations of slots and subslots to be defined. We develop an approach in which given a single cell wireless mesh network using IEEE 802.11 as a reliable message delivery mechanism, one can find upper and lower bounds on the durations of slots. We employ stochastic ordering to compare distributions of random variables and using some properties of stochastic ordering along with the central limit theorem, we devise a way to compute the above mentioned bounds on the durations.

In the second part, we shift our focus to model delays incurred by application packets sent over a WLAN. In this section we model the WLAN as a *Random Polling System*. The packet arrival process at each node i is assumed to be a stationary and independent increment random process with mean a_i and second moment $a_i^{(2)}$. The packet lengths at node i are assumed to be i.i.d random variables P_i with finite mean and second moment. Utilizing available results, we obtain expressions for mean packet delay. Extensive simulations are conducted to verify the analytical results.